CLAIMS

What is claimed is:

1. A laser, comprising:
   a laser gain medium having a first end face and a second end face;
   a low-index optical waveguide integrated with the laser gain medium on a laser substrate and optically end-coupled at its proximal end with the laser gain medium at the first end face; and
   a waveguide grating segment optically coupled to the laser gain medium through the integrated waveguide, the waveguide grating segment providing optical feedback into the laser gain medium to support laser oscillation in at least one optical mode.

2. The laser of Claim 1, wherein the waveguide grating segment forms a portion of the integrated optical waveguide.

3. The laser of Claim 2, wherein the integrated waveguide further comprises a segment, distal to the waveguide grating segment, adapted for transverse-transfer of optical power with another similarly adapted waveguide assembled therewith.

4. The laser of Claim 2, further comprising a second waveguide assembled with the laser so as to establish optical transverse-transfer between the integrated waveguide and the second waveguide at a portion of the integrated waveguide distal to the waveguide grating segment.

5. The laser of Claim 1, wherein the waveguide grating segment forms a portion of a second optical waveguide, the second waveguide provided on a waveguide grating substrate separate from the laser substrate, the laser substrate and the waveguide grating substrate assembled so as to establish optical transverse-transfer between the integrated waveguide and the second waveguide.

6. The laser of Claim 1, wherein the second end face of the laser gain medium provides optical feedback into the laser gain medium to support laser oscillation in at least one optical mode.

7. The laser of Claim 1, further comprising a second optical waveguide optically coupled with the laser gain medium through the second end face.

8. The laser of Claim 7, wherein the second optical waveguide is integrated with the laser gain medium on the laser substrate and optically end-coupled at its proximal end with the laser gain medium at the second end face.

9. The laser of Claim 7, wherein the second optical waveguide has a distal end face, the distal end face providing optical feedback into the laser gain medium to support laser oscillation in at least one optical mode.

10. The laser of Claim 7, wherein the second waveguide includes a corresponding waveguide grating segment thereof, the waveguide grating segment of the second waveguide providing optical feedback into the laser gain medium to support laser oscillation in at least one optical mode.

11. The laser of Claim 10, wherein each of the waveguide grating segments is a sampled grating having a corresponding sampling period, the sampling periods differing from one another so that a change in at least one waveguide grating segment center wavelength results in a larger change in a laser output wavelength.

12. The laser of Claim 7, further comprising a second integrated optical waveguide integrated with the laser gain medium on the laser substrate and optically end-coupled at its proximal end with the laser gain medium at the second end face, wherein the second waveguide is provided on a waveguide substrate separate from the laser substrate, and the laser substrate and the waveguide substrate are assembled so as to establish optical transverse-transfer between the second integrated waveguide and the second waveguide.

13. The laser of Claim 1, wherein the waveguide grating segment enables simultaneous laser oscillation in multiple longitudinal modes.

14. The laser of Claim 13, wherein the waveguide grating segment enables simultaneous laser oscillation in multiple longitudinal modes above about the -20 dB level.

15. The laser of Claim 13, wherein the waveguide grating segment provides reflectivity within about 1% of a peak waveguide grating segment reflectivity simultaneously for multiple longitudinal modes.

16. The laser of Claim 13, wherein the waveguide grating segment provides reflectivity within about 0.5% of a peak waveguide grating segment reflectivity simultaneously for multiple longitudinal modes.

17. The laser of Claim 13, wherein multiple longitudinal modes simultaneously satisfy the condition $\Delta g \cdot L$ greater than about 0.05.

18. The laser of Claim 1, wherein the waveguide grating segment enables laser oscillation substantially restricted to a single longitudinal mode.

19. The laser of Claim 18, further comprising:
   a compensator for controlling a longitudinal mode wavelength;
   at least one wavelength reference and at least one detector for generating a laser-output-wavelength-dependent error signal; and
   a feedback mechanism for controlling the compensator in response to the error signal, thereby maintaining the longitudinal mode wavelength substantially locked with respect to the wavelength reference.

20. The laser of Claim 19, wherein:
   the wavelength reference comprises a pair of reference waveguide grating segments having respective center wavelengths bracketing a center wavelength of the waveguide grating segment, each waveguide grating segment receiving at an input end thereof a portion of laser output and transmitting a fraction of the received portion of the laser output to an output end,
   the detector comprises a pair of photodetectors, each photodetector receiving the transmitted fraction of the laser output from the output end of a corresponding one of the reference waveguide grating segments,
   the error signal is derived from the pair of photodetectors, and
   the feedback mechanism controls the compensator in response to the error signal so as to maintain the longitudinal mode wavelength substantially locked with respect to the center wavelength of the waveguide grating segment.

21. The laser of Claim 20, wherein the waveguide grating segment and the pair of reference waveguide grating segments are formed on a common substrate.

22. The laser of Claim 20, wherein the waveguide grating segment is formed on a first substrate and the pair of reference waveguide grating segments are formed on a second substrate separate from the first substrate.

23. The laser of Claim 19, wherein the compensator comprises a thermo-optic element and a heating element, heating of the thermo-optic element by the heating element shifting a longitudinal mode wavelength of the composite laser resonator.

24. The laser of Claim 19, further comprising a second compensator for controlling a waveguide grating segment center wavelength.

25. The laser of Claim 24, further comprising:

at least one external wavelength reference and at least one secondary detector for generating an secondary laser-output-wavelength-dependent error signal; and

a secondary feedback mechanism for controlling the second compensator in response to the secondary error signal, thereby maintaining the waveguide grating segment center wavelength substantially locked with respect to the external wavelength reference.

26. The laser of Claim 1, wherein the first end face of the laser gain medium is greater than about 5% reflecting and provides, together with the waveguide grating segment, optical feedback into the laser gain medium to support laser oscillation in at least one optical mode.

27. The laser of Claim 26, wherein the reflectivity of the first end face of the laser gain medium is greater than about 10%.

28. The laser of Claim 26, wherein the reflectivity of the first end face of the laser gain medium arises from index contrast between the laser gain medium and the integrated low-index waveguide.

29. The laser of Claim 26, wherein an effective reflectivity yielded by the waveguide grating segment, optical loss at the first end face of the laser gain medium end face, and reflectivity of the first end face of the laser gain medium exceeds an effective

reflectivity yielded by the waveguide grating segment and optical loss at the first end face of the laser gain medium in the absence of reflectivity at the first end face of the laser gain medium.

30. The laser of Claim 26, further comprising a phase compensator for altering the effective optical path length between the waveguide grating segment and the first end face of the laser gain medium, thereby altering an effective reflectivity of the second laser resonator mirror.

31. The laser of Claim 30, wherein the phase compensator is chosen from a set of phase compensators having discrete relative phase shifts ranging between 0 and 2π.

32. The laser of Claim 30, wherein the phase compensator provides a variable phase shift in response to a control signal.

33. The laser of Claim 30, wherein the phase compensator is structurally altered during fabrication of the laser so as to provide a desired phase shift.

34. The laser of Claim 1, wherein properties of the waveguide grating segment vary along its length according to an apodization function.

35. The laser of Claim 1, further comprising a reflective coating between the waveguide grating segment and a substrate on which the waveguide grating segment is formed.

36. The laser of Claim 35, wherein a lower cladding thickness of the waveguide grating segment is selected so as to at least partially suppress diffraction into an unwanted diffracted order of the waveguide grating segment.

37. A laser, comprising:

a laser gain medium having a first end face and a second end face;

a waveguide grating segment optically coupled to the laser gain medium through the first end face, the waveguide grating segment providing optical feedback into the laser gain medium to support laser oscillation substantially restricted to a single longitudinal mode;

a compensator for controlling a longitudinal mode wavelength;

a pair of reference waveguide grating segments having respective center wavelengths bracketing a center wavelength of the waveguide grating segment, each waveguide grating segment receiving at an input end thereof a portion of laser output and transmitting a fraction of the received portion of the laser output to an output end;

a pair of photodetectors, each photodetector receiving the transmitted fraction of the laser output from the output end of a corresponding one of the reference waveguide grating segments; and

a feedback mechanism for controlling the compensator in response to an error signal,

wherein

the error signal is derived from the pair of photodetectors, and

the feedback mechanism controls the compensator in response to the error signal so as to maintain the longitudinal mode wavelength substantially locked with respect to the center wavelength of the waveguide grating segment.

38. The laser of Claim 37, wherein the waveguide grating segment and the pair of reference waveguide grating segments are formed on a common substrate.

39. The laser of Claim 37, wherein the compensator comprises a thermo-optic element and a heating element, heating of the thermo-optic element by the heating element shifting a longitudinal mode wavelength of the composite laser resonator.

40. The laser of Claim 37, further comprising a second compensator for controlling a waveguide grating segment center wavelength.

41. The laser of Claim 40, further comprising:

at least one external wavelength reference and at least one secondary detector for generating an secondary laser-output-wavelength-dependent error signal; and

a secondary feedback mechanism for controlling the second compensator in response to the secondary error signal, thereby maintaining the waveguide grating segment center wavelength substantially locked with respect to the external wavelength reference.